
EERC
Critical Challenges.
Practical Solutions.

DEVELOPING AND VALIDATING RESERVOIR PRESSURE MANAGEMENT AND PLUME CONTROL STRATEGIES IN THE WILLISTON BASIN THROUGH A BRINE EXTRACTION AND STORAGE TEST (BEST)

Carbon Capture, Utilization & Storage Conference

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Critical Challenges. Practical Solutions.

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Thank You
Project Partners

Acknowledgments

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Active Reservoir Management (ARM)

Why ARM?

- Reduce stress on sealing formation
- Divert pressure from leakage pathways
- Reduced area of review (AOR)
- Improve injectivity

Why Brine Treatment?

- Alternate source of water
- Reduce disposal volumes
- Salable products for beneficial use

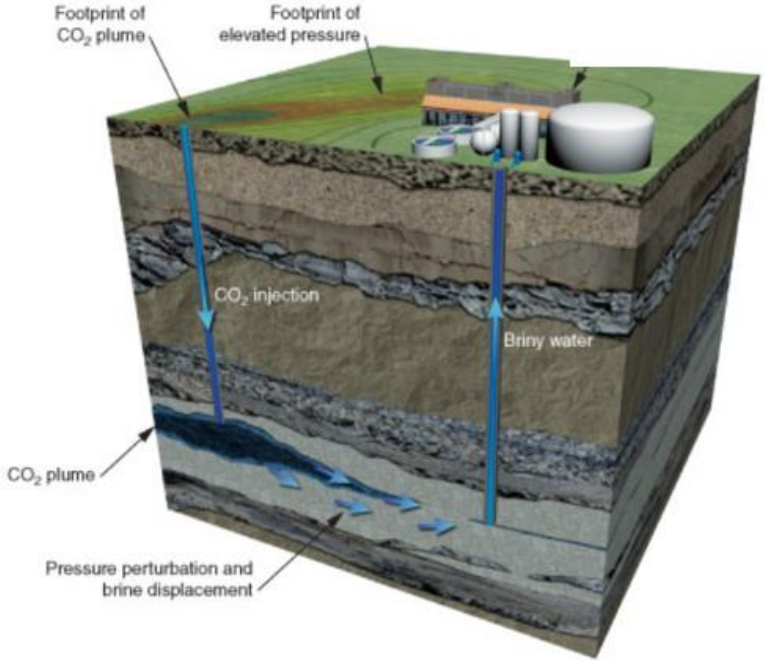
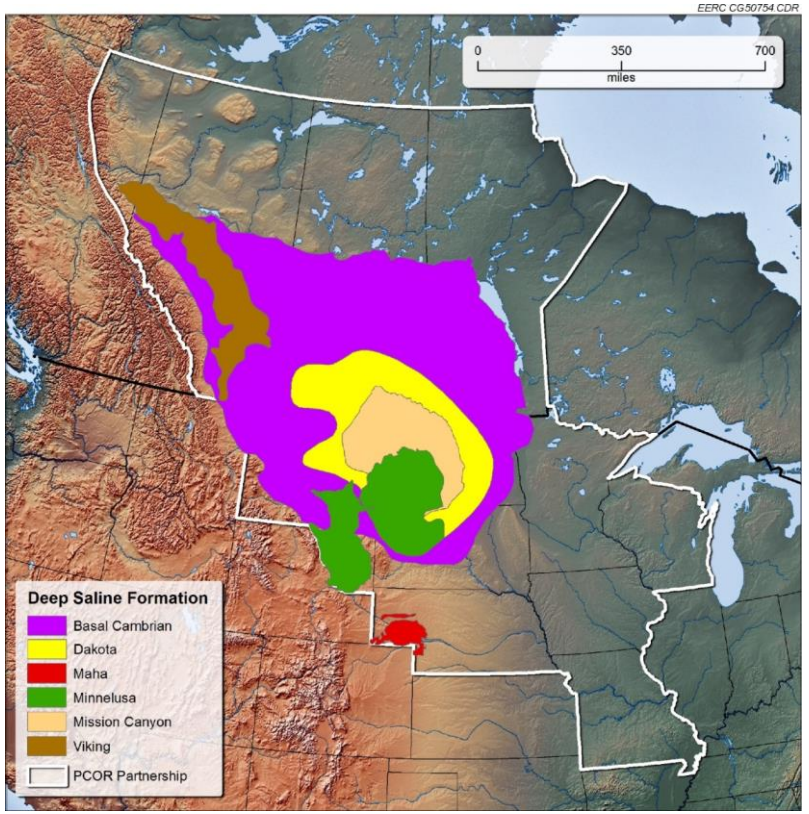


Photo Modified from Lawrence Livermore National Laboratory
https://str.llnl.gov/Dec10/aines.html

Phase 1

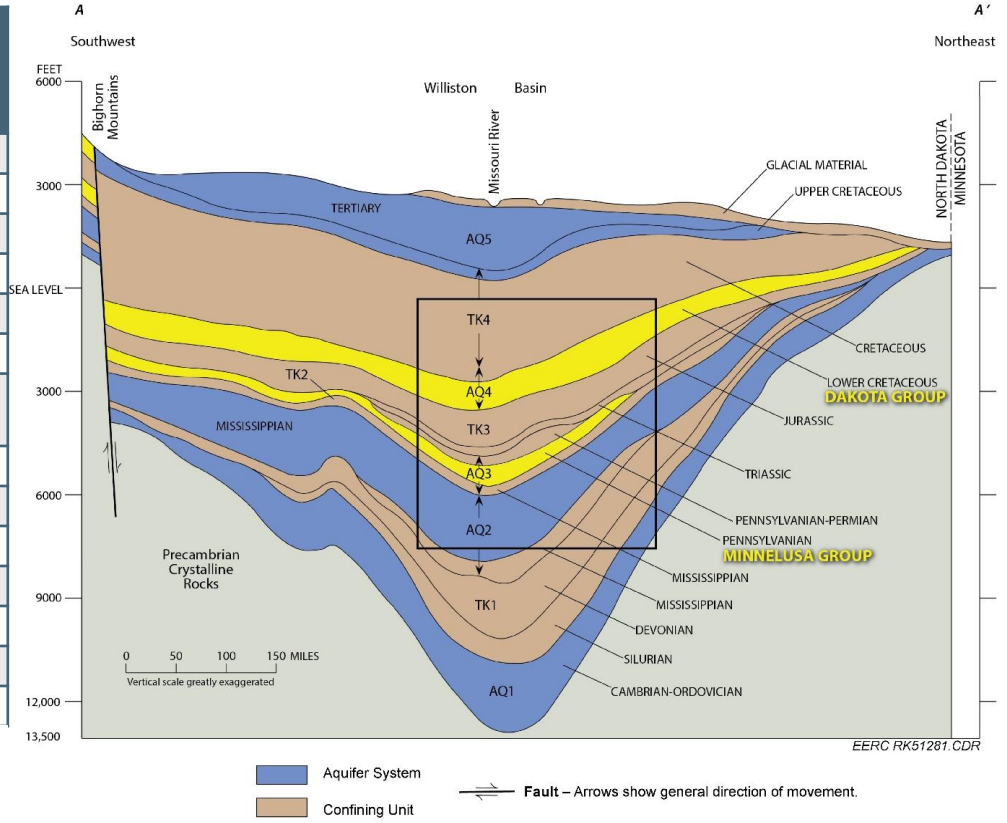
- Regional characterization
- Site screening and feasibility study
- Site selection
- Geologic modeling
- Reservoir simulation resulting in ARM schema
- Site infrastructure design and field implementation plan
  - Permitting plan
  - Risk assessment
  - MVA plan
  - Site operations plan
  - Costing analysis
  - Brine treatment technology screening and selection process



The Williston Basin

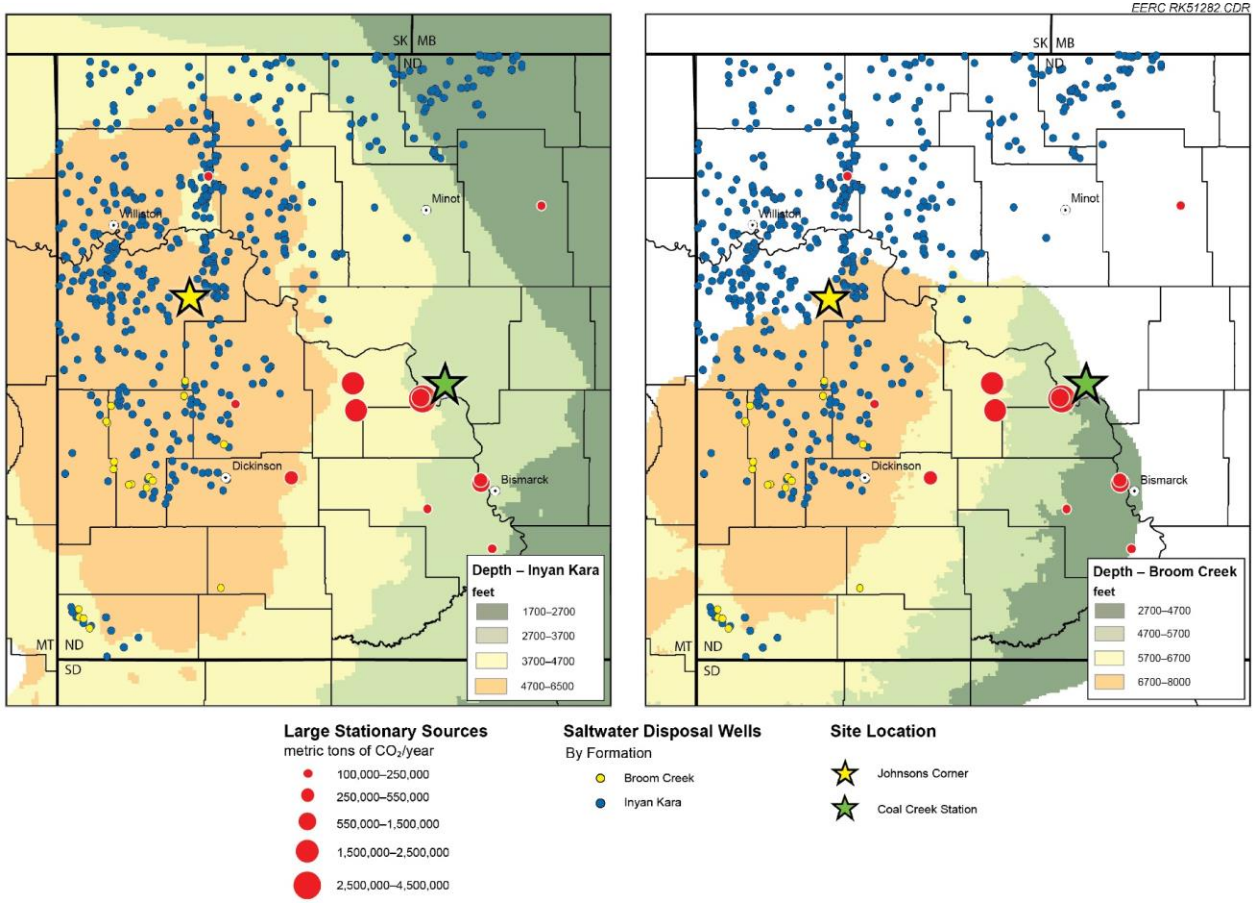
Saline Formation	CO_2 Storage Volume (billions of tons)
Basal Cambrian	222–720
Beaverhill Lake Group	<1–5
Minnelusa (Williston Basin)	124–451
Elk Point Group	1–12
Dakota	135–438
Maha	21–68
Minnelusa (Powder River Basin)	10–35
Mission Canyon	65–210
Red River	2–6
Rundle Group	1–8
Viking	20–65
Winterburn Group	1–6
Woodbend Group	1–5
Total	**604–2031**

CO_2 Storage in Saline Formations in the PCOR Partnership Region (in billions of tons of CO_2) (modified from Glazewski and others, 2015)



Dakota & Minnelusa Groups

- Regional injection targets (CO_2 and saltwater)
- Demonstrated capacity
- Excellent proxy for CO_2 injection into deep saline formations (DSFs)
  - Distributed well network
  - Open DSF system
  - ARM will influence multiple square miles of formation



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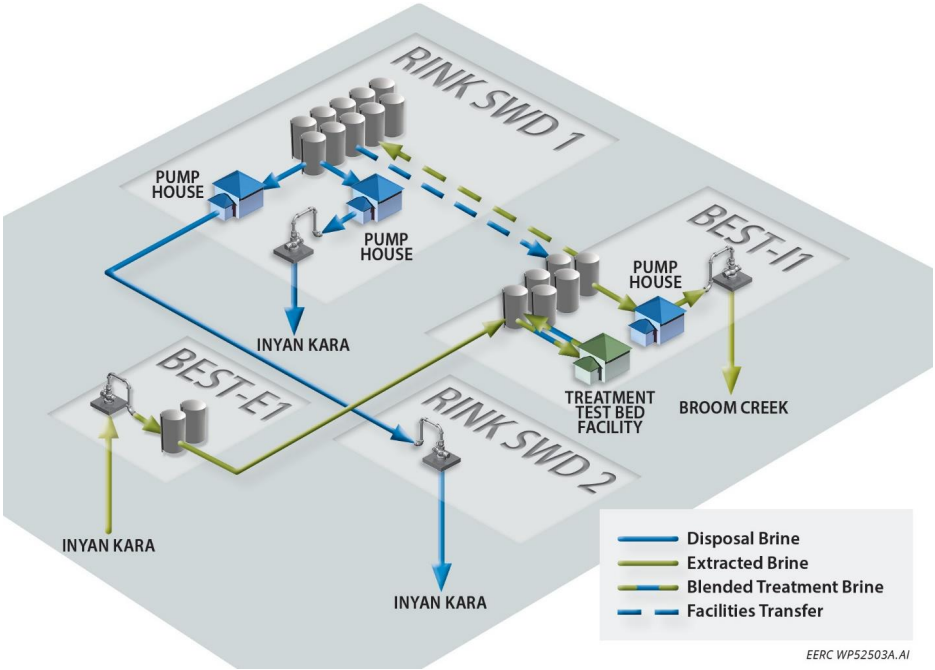
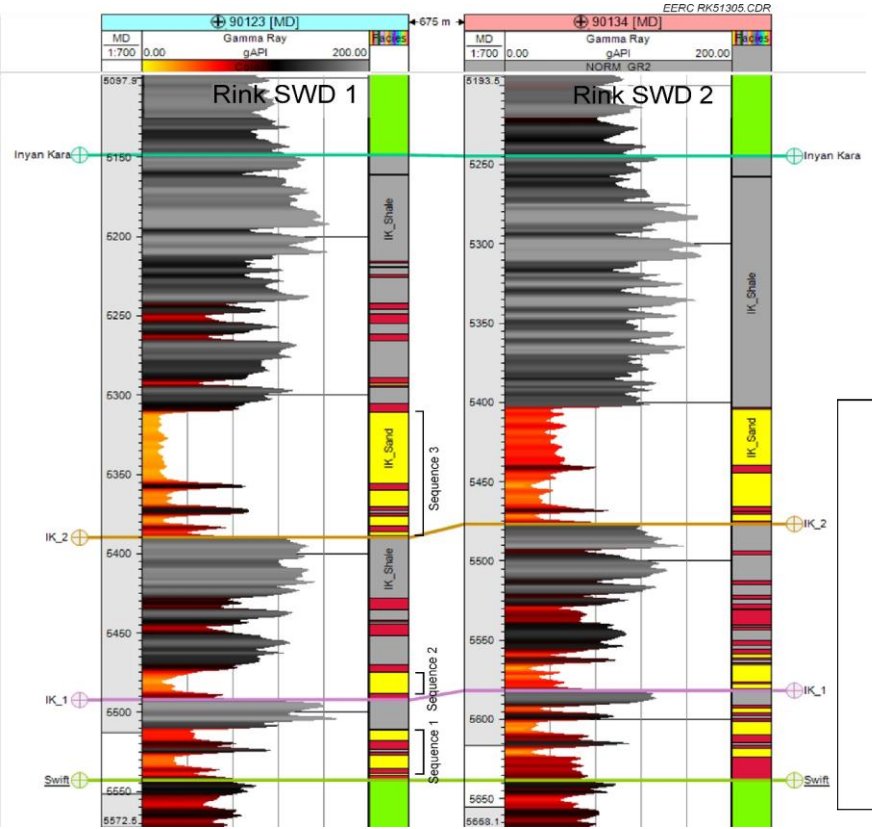
Field Implementation Plan (FIP)

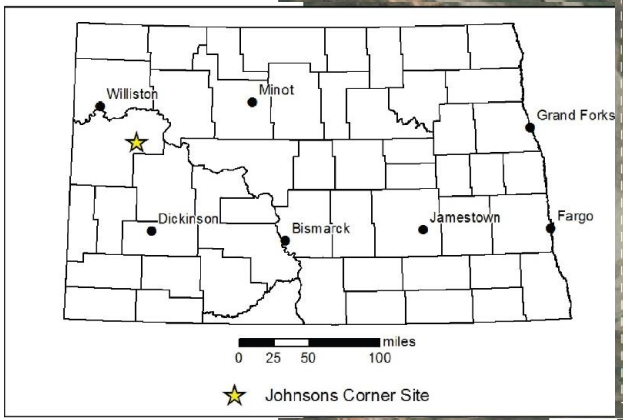
- Develop ARM strategies
- Validate performance against forecasts
- ARM economics
- Monitoring techniques
- Brine treatment technology test bed
- Demonstrate ARM implementation and operations



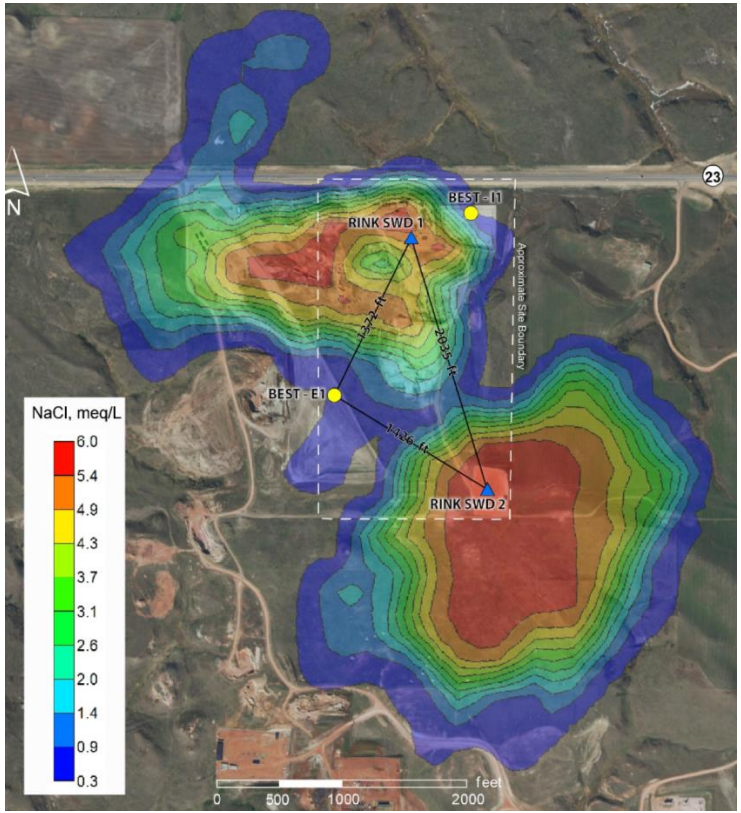
The Site

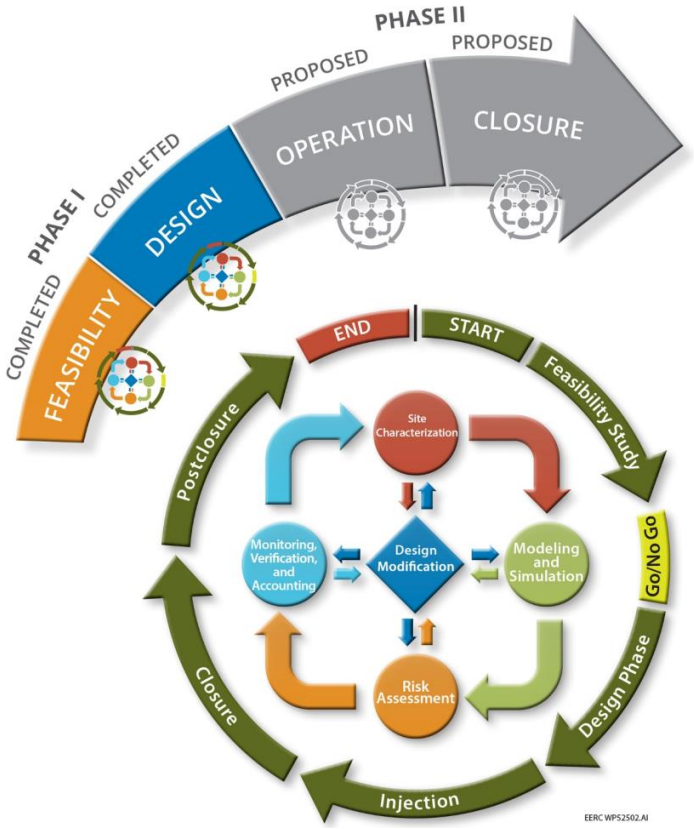
Formation	Inyan Kara	Broom Creek
Depth, ft	4927–5359	7248–7630
Thickness, ft	338–475	46–113
Average Thickness, ft	390	76



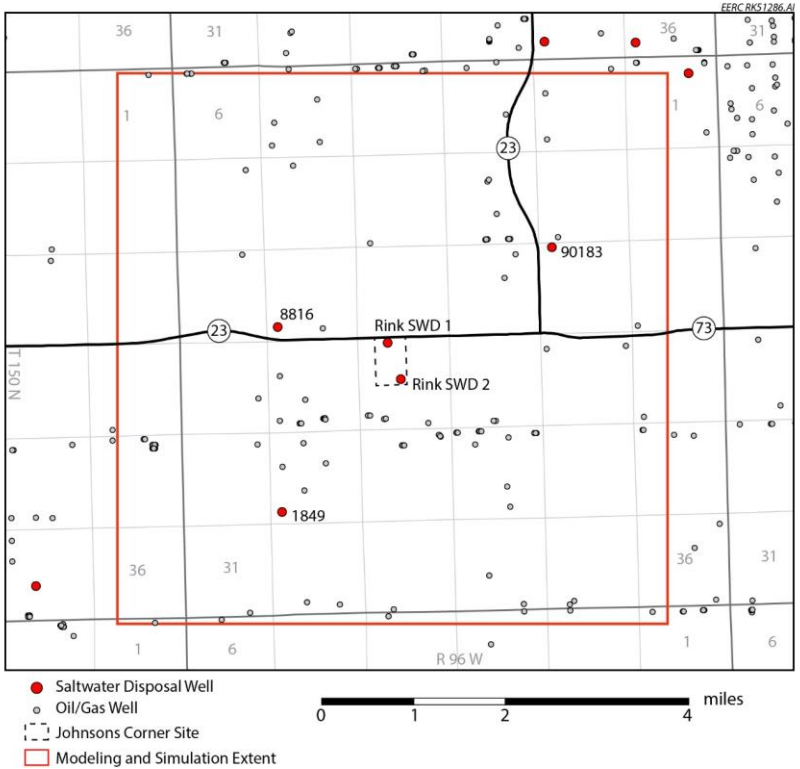


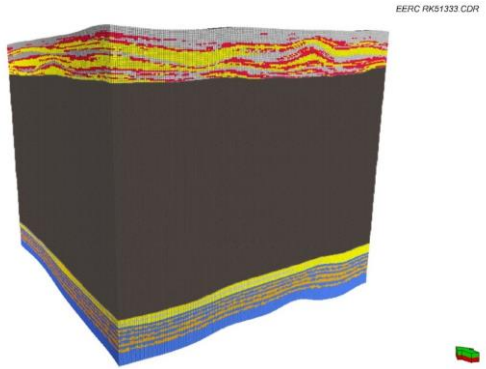
The Design (Balance)

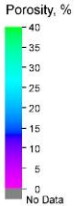


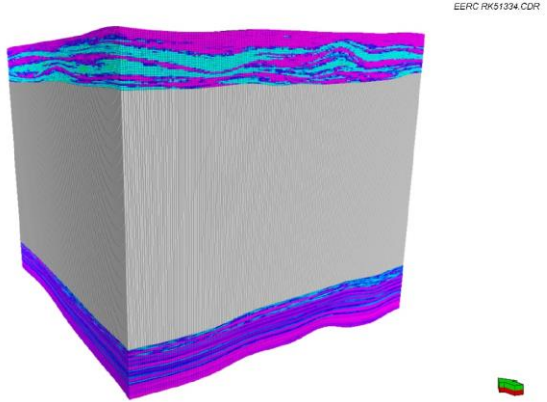


Geomodeling

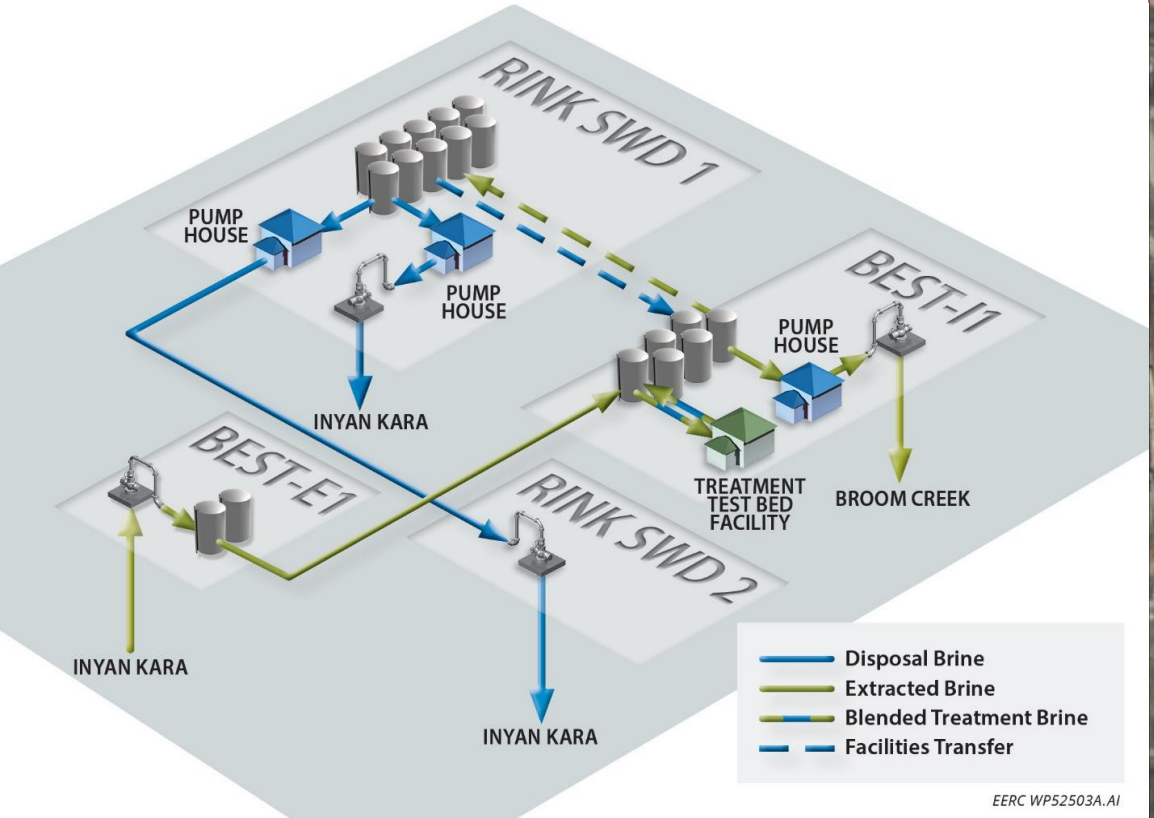


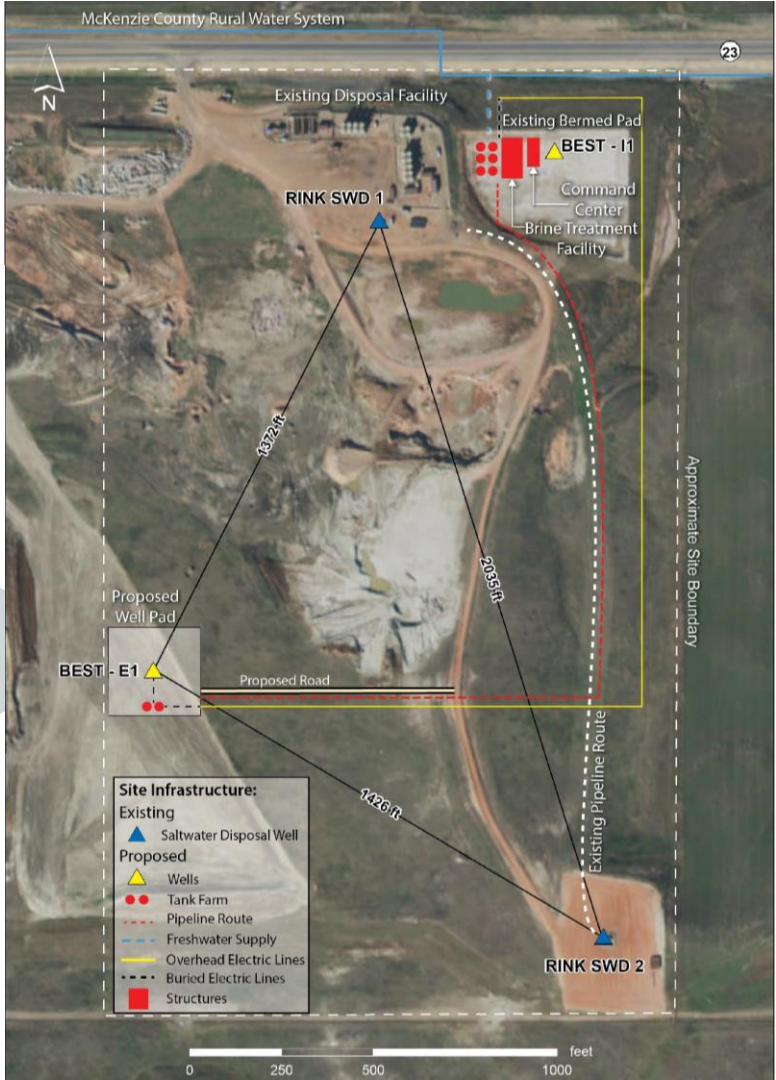




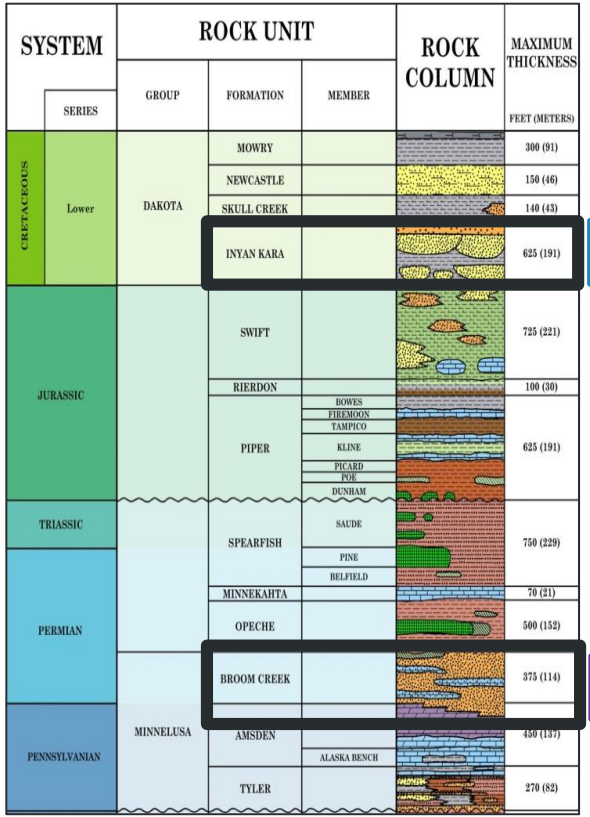


Infrastructure





Well Completions

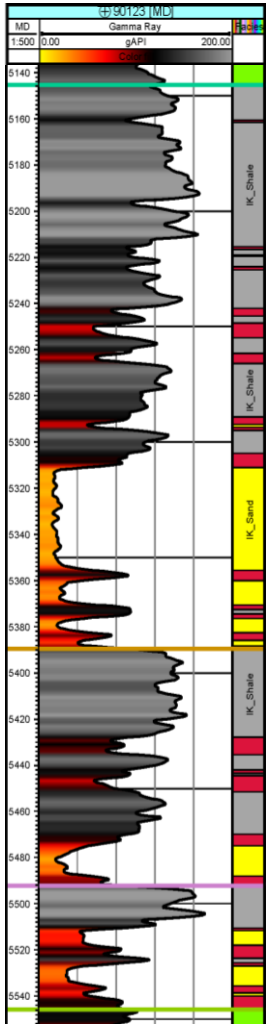


Estimated Perforated Intervals

BEST-E1

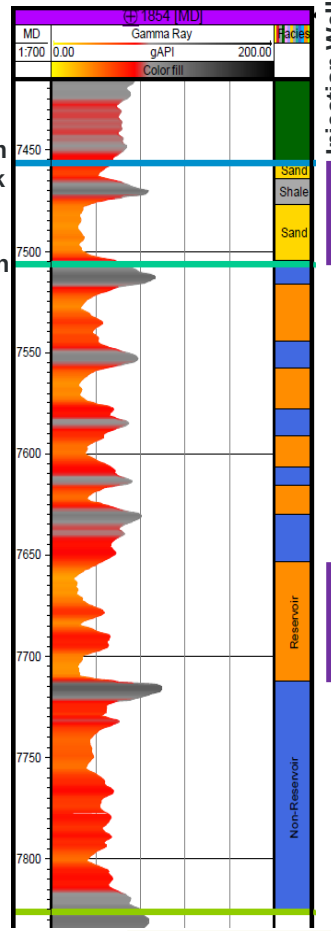
BEST-I1

Inyan Kara



Extraction Well (BEST E-1)

Swift

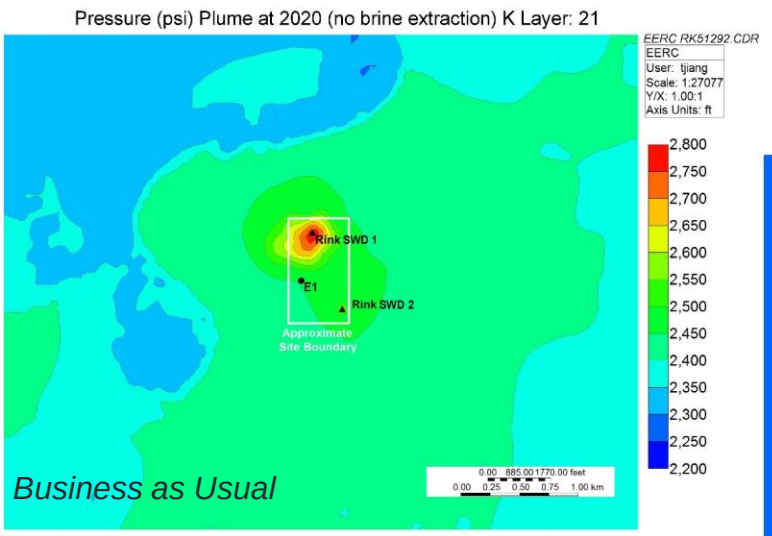


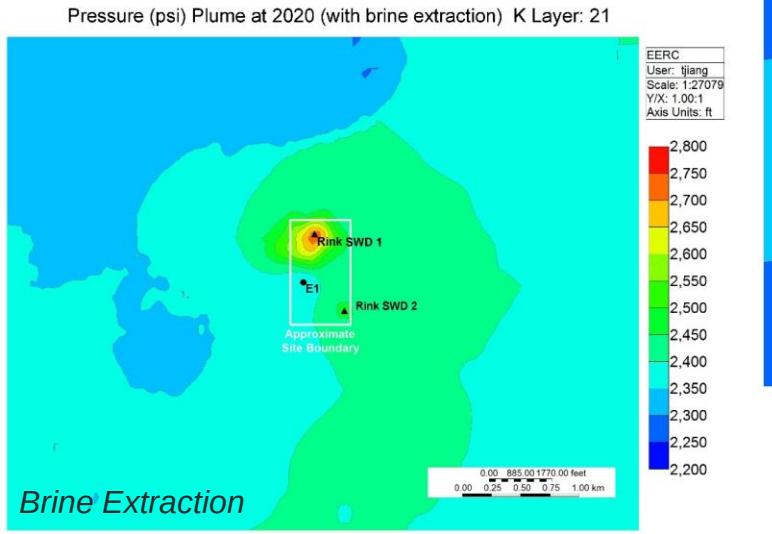
Broom Creek

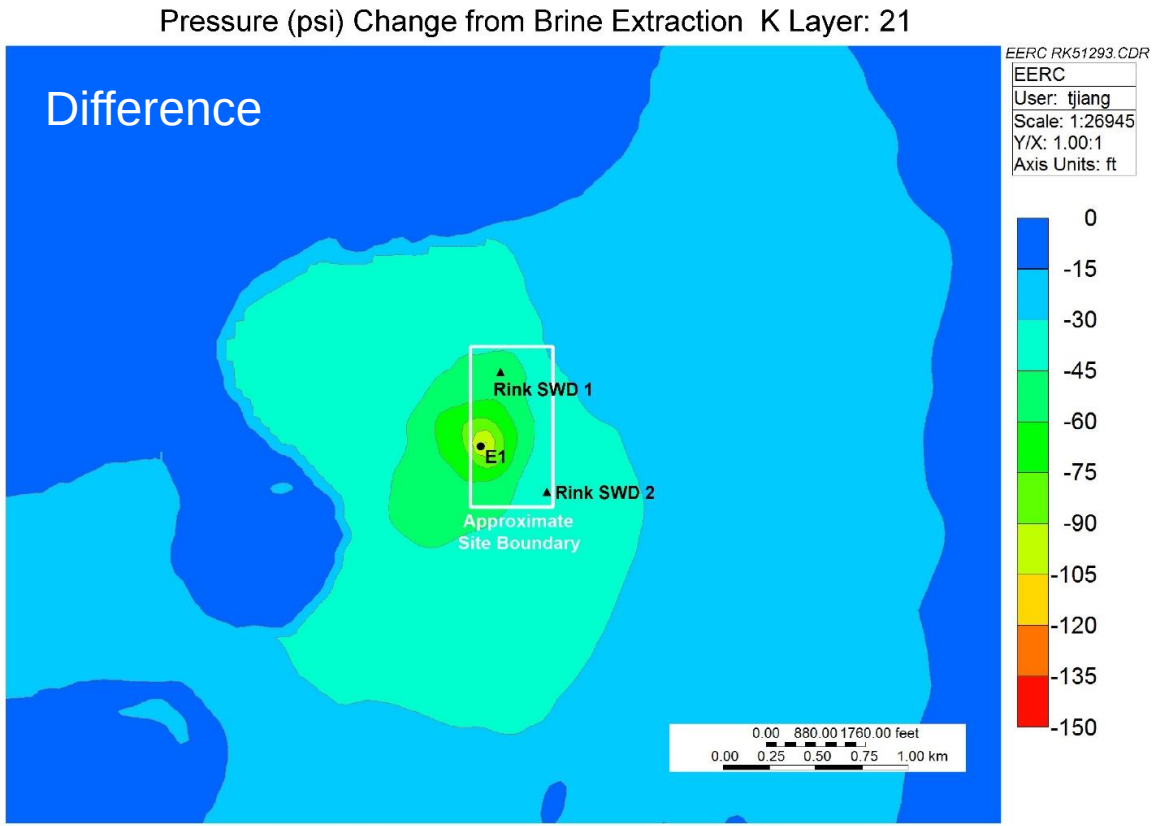
Amsden

Injection Well (BEST I-1)

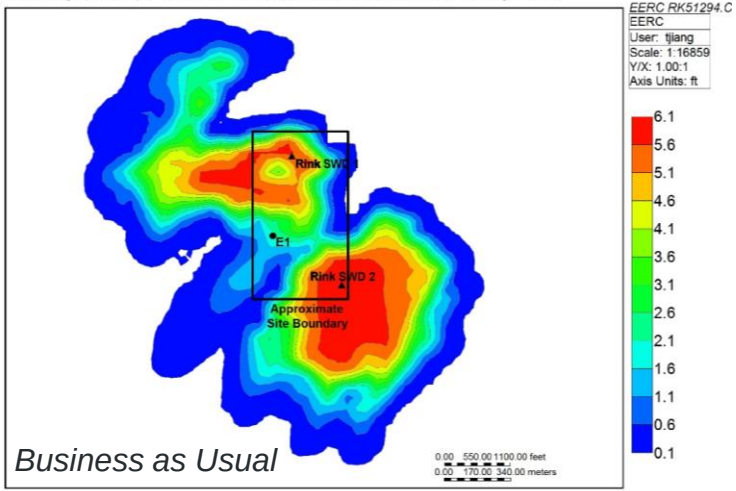
Critical Challenges. **Practical Solutions.**


Pressure (psi) Plume at 2020 (no brine extraction) K Layer: 21
EERC RK51292.CDR
EERC
User: tjiang
Scale: 1:27077
Y/X: 1.00:1
Axis Units: ft
2,800
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
Rink SWD 1
E1
Rink SWD 2
Approximate
Site Boundary
0.00 885.00 1770.00 feet
0.00 0.25 0.50 0.75 1.00 km
Business as Usual


Pressure (psi) Plume at 2020 (with brine extraction) K Layer: 21
EERC
User: tjiang
Scale: 1:27079
Y/X: 1.00:1
Axis Units: ft
2,800
2,750
2,700
2,650
2,600
2,550
2,500
2,450
2,400
2,350
2,300
2,250
2,200
Rink SWD 1
E1
Rink SWD 2
Approximate
Site Boundary
0.00 885.00 1770.00 feet
0.00 0.25 0.50 0.75 1.00 km
Brine Extraction

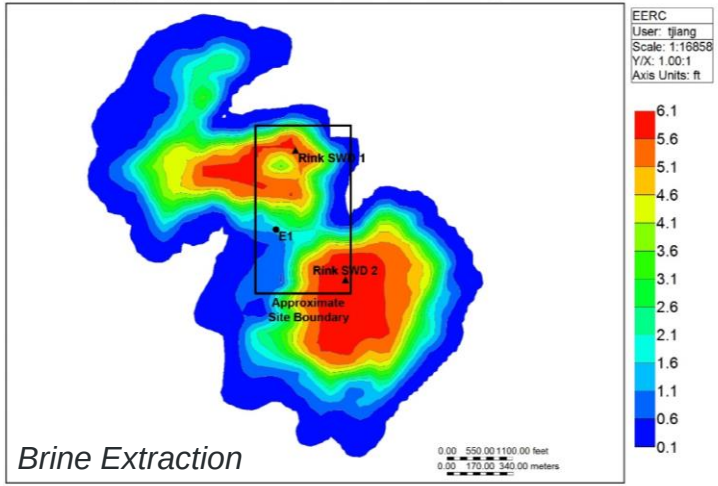

Pressure (psi) Change from Brine Extraction K Layer: 21
Difference
EERC RK51293.CDR
EERC
User: tjiang
Scale: 1:26945
Y/X: 1.00:1
Axis Units: ft
0
-15
-30
-45
-60
-75
-90
-105
-120
-135
-150
Rink SWD 1
E1
Rink SWD 2
Approximate
Site Boundary
0.00 880.00 1760.00 feet
0.00 0.25 0.50 0.75 1.00 km

Salinity (molar) Plume at 2020 (no brine extraction) K Layer: 21



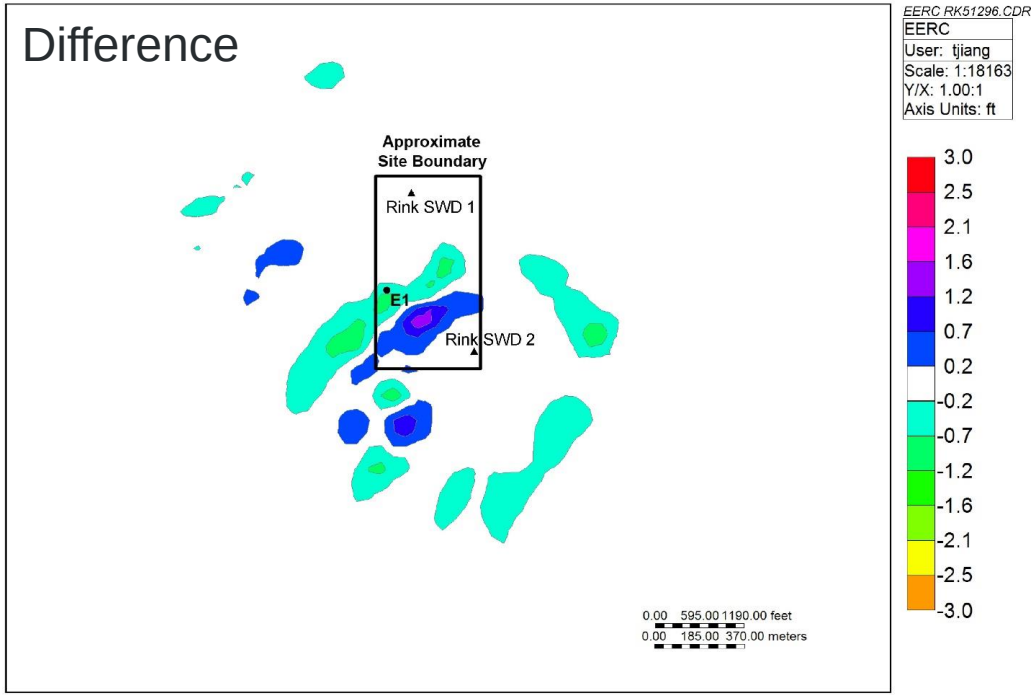
Business as Usual

Salinity (molar) Plume after Brine Extraction K Layer: 21

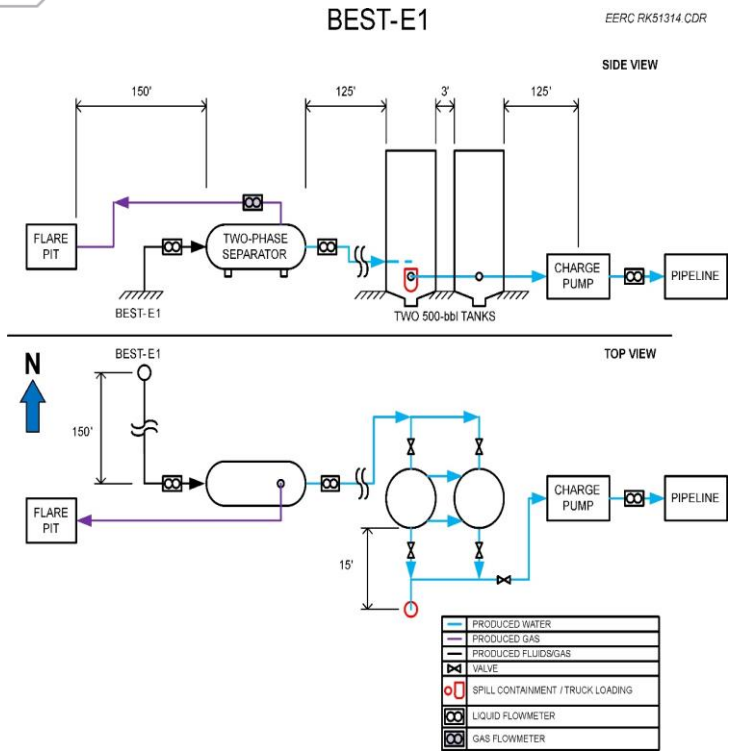


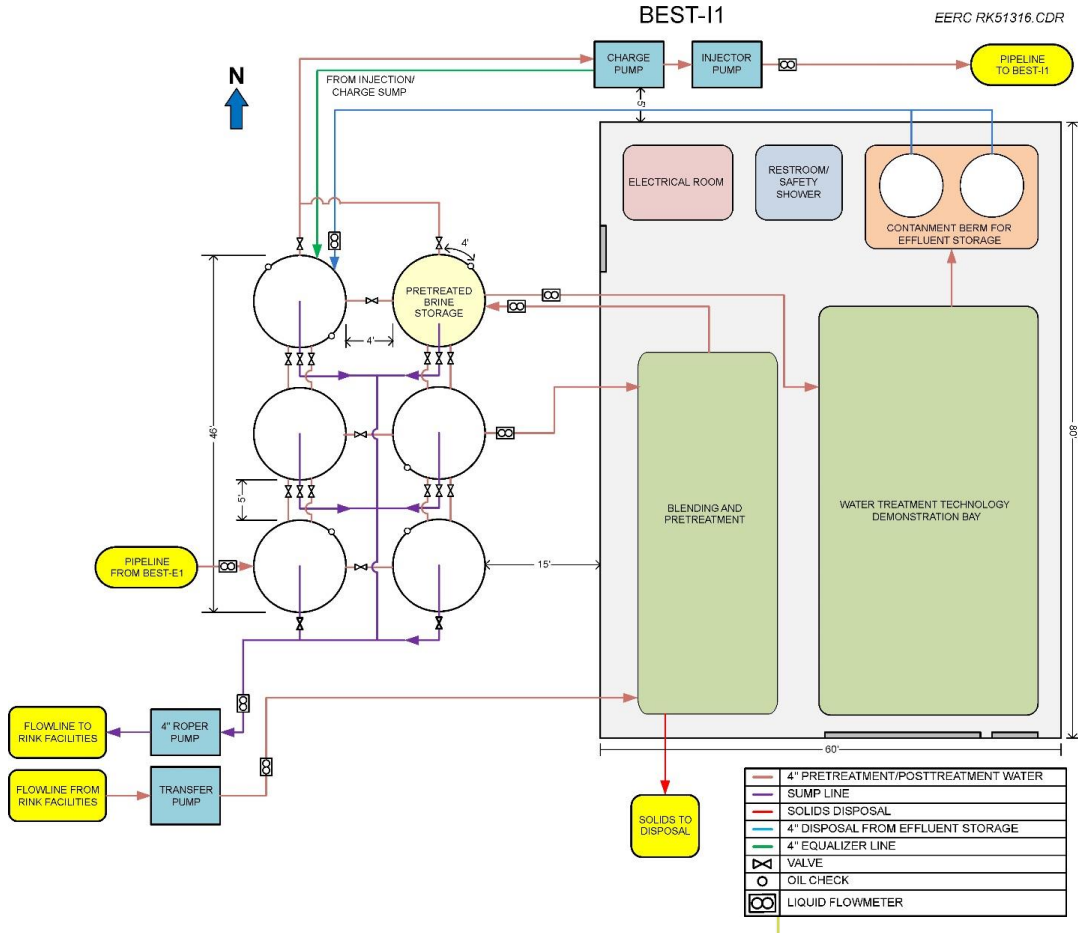
Brine Extraction

Salinity (molar) Change from Brine Extraction K Layer: 21



Brine Handling





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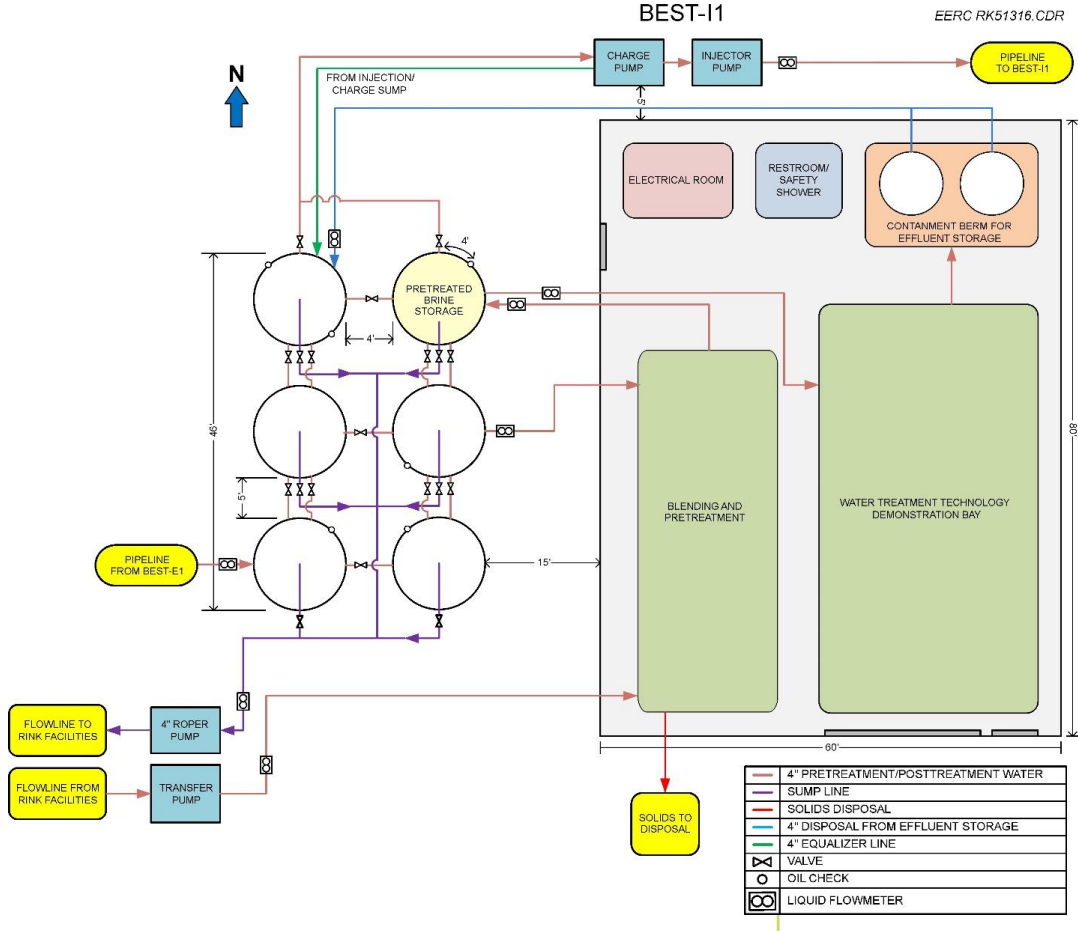
Brine Treatment Test Bed

- Environmentally enclosed facility
  - 24/7, 365 operational capable
- Tailored brine compositions
  - ~4500–300,000 mg/L TDS
- Tailored rates
  - 5–25 gpm
- 30–60-day extended-duration tests
- Pretreatment provided
- Monitoring
  - Energy, flow rates, pressure, temperature, chemicals, etc.
- Waste management

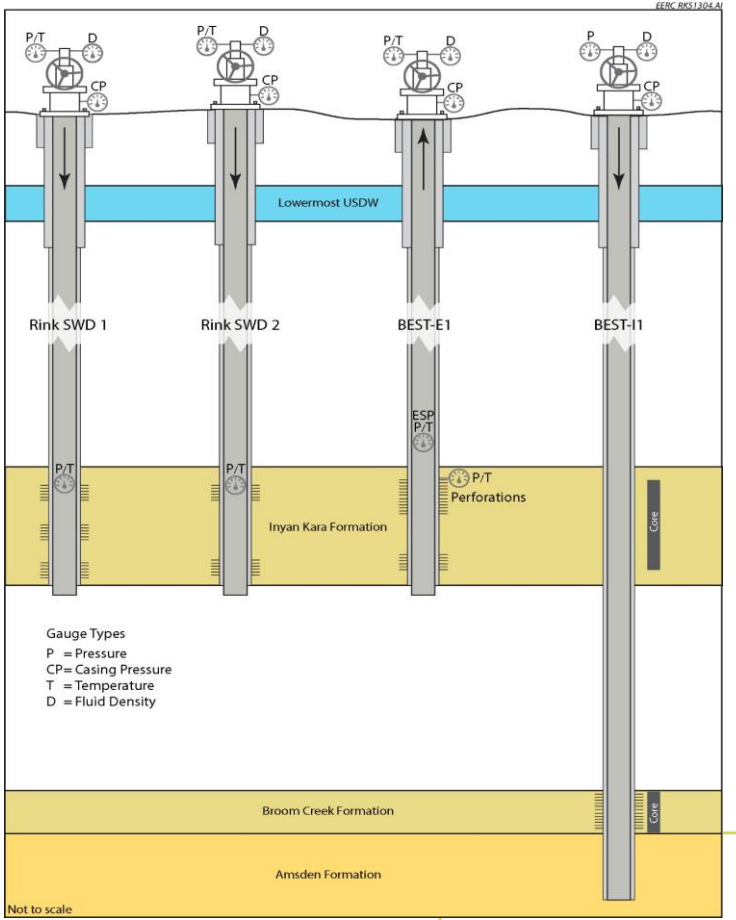
<u>Technologies Selected in Phase 2</u>



MVA Program

Reservoir Surveillance
- Well evaluation
  - Logging, coring, testing
- Borehole to surface EM
- Active reservoir surveillance
  - Pressure, temperature, flow rates, fluid density
- Tracer survey
- Fluid sampling

Safety and Performance
- Tank and pipeline monitoring
- Flow and density meters
- Power and chemicals
- Pipeline monitoring
- High-level/low-level shutdown
- Remote sensing



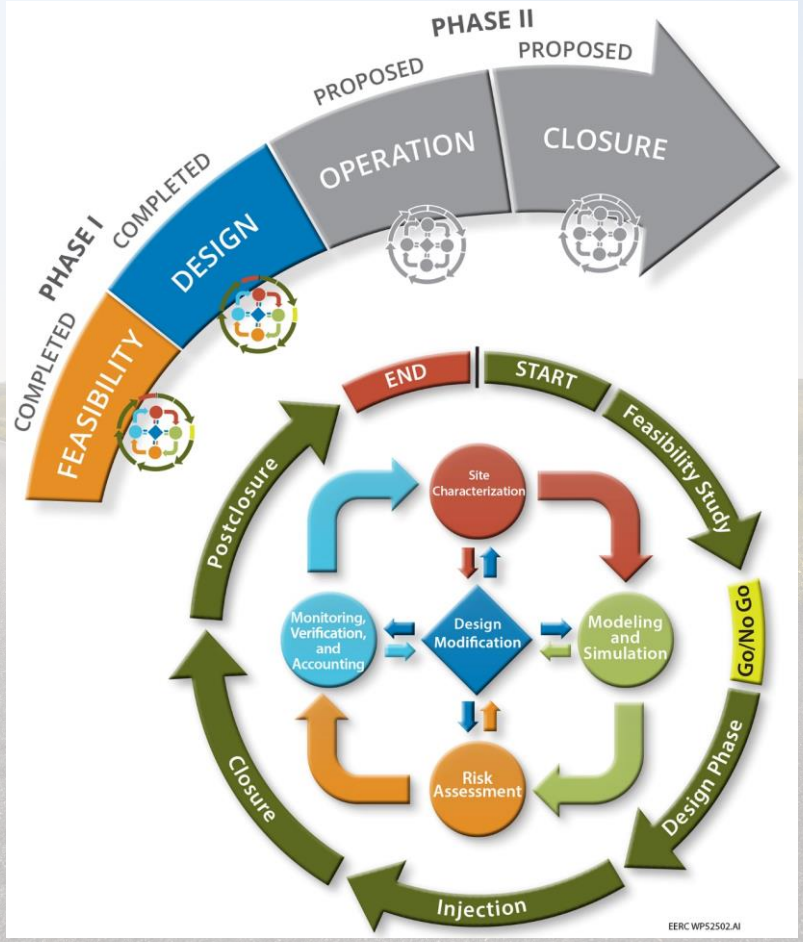
Risk Assessment

- 58 potential risks
  - Technical
  - Resource availability
  - HSE
  - Site access
  - Management
- Mitigation measures built into design and implementation plan
- MVA and HSE plans

Ready for Implementation

- ☑ Strong partnerships/extensive experience
- ☑ Site secured
- ☑ Established injectivity/injection history
- ☑ Existing pressure plume/confidence in ability to influence through brine extraction
- ☑ Operational flexibility (four-well design)
- ☑ Brine treatment test bed
- ☑ Commercial-scale test
- ☑ MVA plan (performance and safety)
- ☑ Permitting plan (several in place)
- ☑ Costing
- ☑ Risk assessment

Developing fundamental data and demonstrating the steps necessary to design and implement ARM for large-scale CCS projects.



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THANK YOU!

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Contact Information

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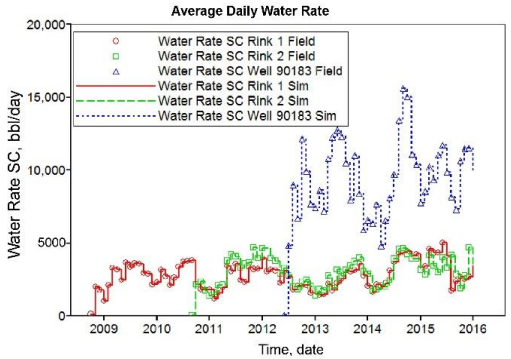
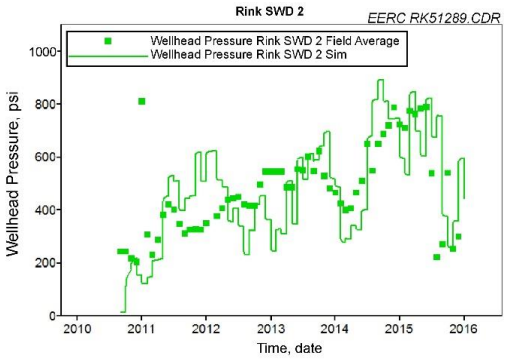
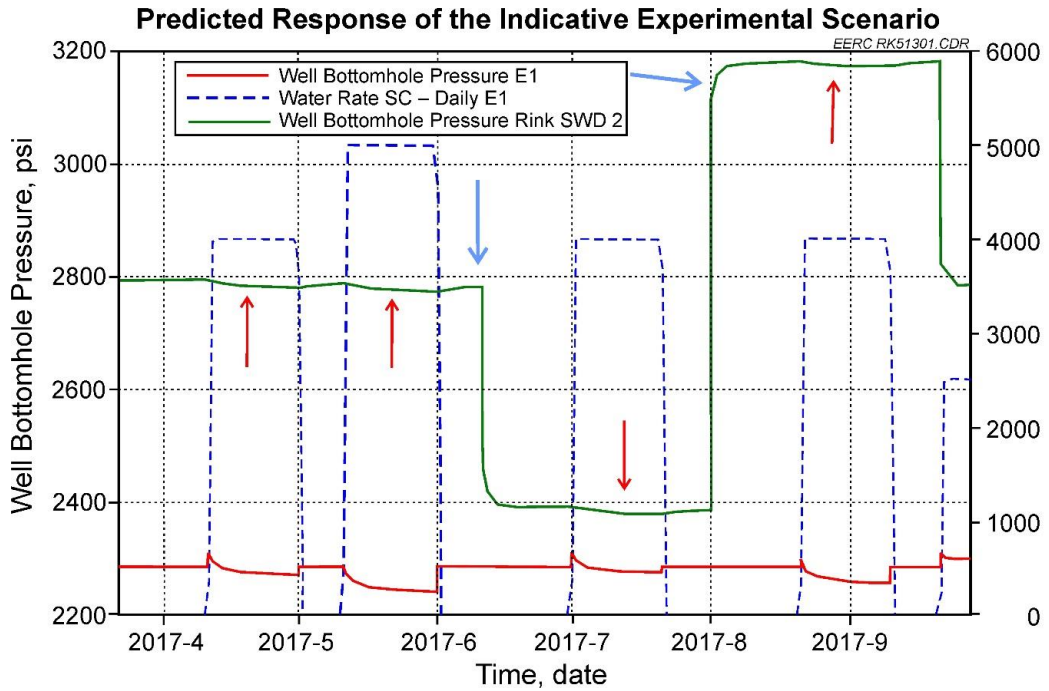
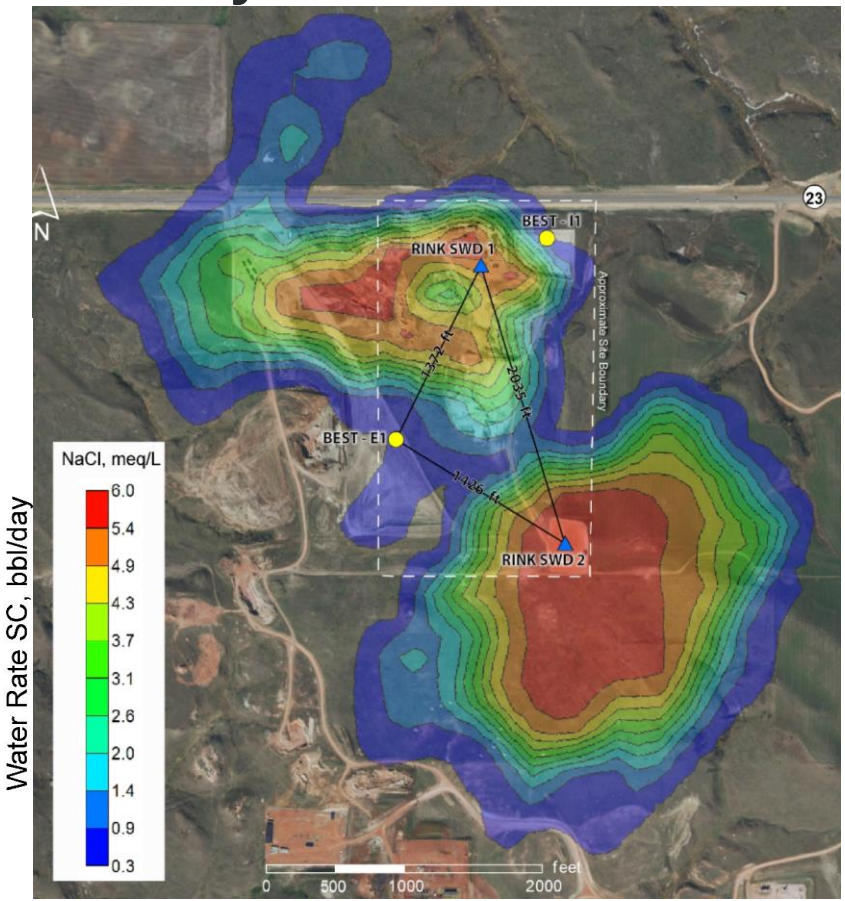
Dynamic Simulation









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